VOLUME 3

chapter 12

RESILIENCE: LIVING WITH WATER AND NATURAL HAZARDS

A Context

New Orleans has always depended for its existence and prosperity on its location in a place prone to storms, floods, and other natural challenges. It was founded, grew, and prospered by taking advantage of the strategic and commercial value that its proximity to America's greatest river and the Gulf of Mexico offered. Understanding and managing risks to secure this opportunity and value has been the story of New Orleans, and it remains a key to the city's future. The primary hazard New Orleans continues to face is flooding, a risk that comes from three distinct sources: flooding from the Mississippi River, heavy rains, and hurricane-related storm surge, all of which are exacerbated by the city's low-lying, or below sea-level terrain. Other hazards include wind, erosion, rising heat and sea level, and pollution and chemical spills. The focus in this discussion is on flood hazards.

New Orleans' location has been the source of both vulnerability and prosperity throughout its history.

Although the language of storm experts has become a common currency in New Orleans, with people talking about 1-in-100-year or 1-in-1,000-year storms, the fact that these are simply probabilities based on past experience is not as well understood. Because of a variety of conditions, probabilities may be changing and are therefore difficult to predict. The concept of risk is also more complex and variable than most people generally think because risk is not only linked to probability but to consequences. For example, the annual 1 percent probability of a 100-year storm means there is a 39 percent probability of the storm over 50 years. This can be more or less risky, depending on the situation and on actions taken to reduce the consequences of a storm. Moreover, a "1-in-100-year storm" does not mean that a storm of this magnitude would really strike at this frequency. Multiple 100-year storms could strike New Orleans in consecutive years or even in the same hurricane season.

Hazard mitigation means "any sustained action taken to reduce or eliminate the long-term risk to human life and property from hazards."[1] Mitigating risks is nothing more than the act of taking steps to avoid or reduce the negative impacts of foreseeable events. It is something people and communities do—and have done forever under any number of other names such as common sense, prudence, responsibility and experience. To be effective, hazard mitigation must be targeted to all classes and types of hazards; and it must be comprehensive in its approach, integrated in its implementation, and mindful of the community interests it wants to protect or enhance.

In the 21st century, the language of hazard mitigation is coupled with the concept of "resilience." Resilience is shown by a community's "capacity to anticipate significant multi-hazard threats, to reduce overall the community's vulnerability to hazard events, and to respond to and recover from

[1] 44 CFR. Part 201.2—Federal Definition

specific hazard events when they occur."[2] However, a new aspect of resilience is increasingly added to this concept. Resilience is not just the capacity to return to a previous state—it includes "the capacity to cope with and recover from present-day risks and the capacity to adapt to changing conditions, including uncertain, unknown, or unpredictable risks."[3] This means that communities need to be able to "learn, adapt, and change," and the "recovery toward a more resilient state is not automatic, nor is it guaranteed."[4]

Since Hurricane Katrina, many New Orleanians have become interested in the way that the Dutch have for centuries reclaimed land from the sea, lived below sea level, and used canals both for function and to beautify their cities. The Dutch polder system—in its physical meaning—has attracted attention. But there is another common, political meaning that Europeans attach to the words, "polder system," which it is worthwhile to ponder. It means a consensus- and community-based approach to economic decision-making. Everyone who lives in the same polder has to cooperate to maintain the dikes and pumps that keep water from rushing in to destroy the polder. Even when cities in the same polder were at war, they had to cooperate in keeping up the polder for everyone.

To become a resilient, adaptable community that can plan to manage the physical, environmental, social and economic stress of storms and flooding before such events occur, effectively rebound from crisis situations, and adjust in light of future changes or uncertainties, New Orleans must become the expert on its own protection, hazard mitigation and overall resilience. Technical expertise within city government must be combined with a broad community dialogue and understanding about environmental hazards, probabilities, managing risks, and the interrelated responsibilities of individual households, municipal/parish, the state and federal governments. Through the right set of policies and strategies, New Orleans will become a more livable, prosperous and sustainable city that thrives not in spite of its presence to water, but because it has better learned to live with water by managing its risk more effectively through a comprehensive, multiple lines of defense strategy of overall resilience.

1. Risk, Recovery and Resilience Before Hurricane Katrina[5]

Hurricanes in 1722 and 1723 introduced the early French settlers to the natural risks of New Orleans' site and there have been 27 major floods between the founding of the city and 2009. Before the twentieth century, the community—as individuals and as a local government—had responsibility for responding to floods and other hazards, which included non-flood threats, such as yellow fever epidemics. Organizations like the Red Cross and the National Guard, as well as big companies that owned infrastructure like railroads and utilities, became involved in storm response in the early twentieth century, and after the 1947 hurricane, federal assistance became more prominent. The combination of a history of hazards and a thriving international port economy meant that the city leadership was always anxious to send the message that everything returned quickly to normal. Before the 1960s, however, there was not a large population living in the most vulnerable areas of New Orleans.

Hurricane Betsy in 1965 was a turning point in the history of risk and approach to mitigation in New Orleans. This hurricane had the most devastating impact on the city up to that point—flooding 43 percent of the city and damaging over 14,000 homes. Quick immediate clean up and repair was followed within a few years by a series of actions and broader events that resulted in a less, rather than more, resilient city:

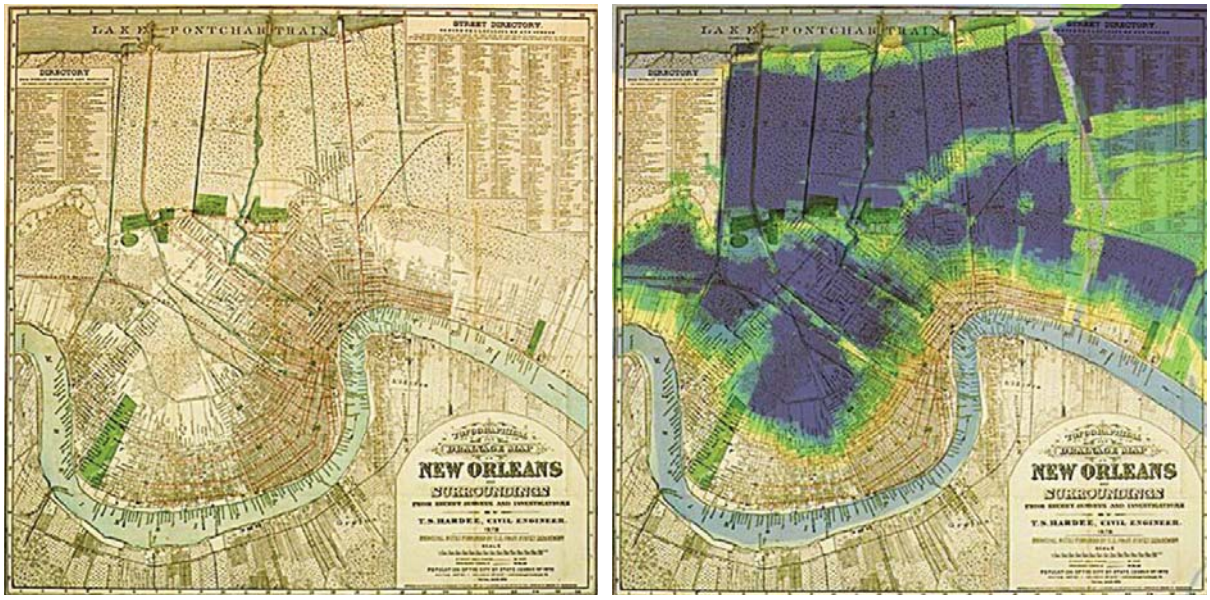
- Congress appropriated additional funds to strengthen the regional levee system and the National Flood Insurance Program, with a promised protection level for a 1-in-200-year storm. The hurricane

[2] C.E. Colton, R.W. Kates, and S. B. Laska, *Community Resilience: Lessons from New Orleans and Hurricane Katrina*, CARRI Research Report 3 (September 2008), p.3. (Community and Regional Resilience Initiative of the Oak Ridge National Laboratory, www.resilientUS.org.)

[3] Susanne C. Moser, *Resilience in the Face of Global Environmental Change*, CARRI Research Report 2 (September 2008), p. 32.

[4] *Ibid.*

[5] The information and discussion in this section is greatly indebted to Colton, *et al., Community Resilience.*



Historical extent of the city's street grid as shown on the 1878 Hardee map and 1878 map with Hurricane Katrina flood depths superimposed shows that most areas that flooded after Hurricane Katrina were not settled in 1878.

protection program remained incomplete when Hurricane Katrina arrived 40 years later.

- The Army Corps of Engineers improved levees around the city core and New Orleans East, Jefferson Parish and St. Bernard Parish, but did not provide protection from storm surges or from a 1-in-100-year flood.
- Levee and canal building contributed to coastal erosion.
- Population increased in the most flood prone areas of the city and in previously uninhabitable parts of New Orleans East, as well as the suburban parishes.
- Drainage pumps dried out parts of the city, soil subsidence inside the levees increased, and a bowl effect resulted, with more frequent flooding from rain storms.
- Rain storm flooding in vulnerable areas such as Broadmoor was reduced significantly by the Army Corps of Engineers Southeast Louisiana Drainage Project, which enlarged drainage and pump capacity.
- Participation in the National Flood Insurance Program in New Orleans tended to be more frequent in the areas with a history of stormwater flooding, and not where risk from hurricanes was greatest.
- Inconsistent building code enforcement detracted from official protection measures.

All of these activities during the 40 years between Hurricane Betsy and Hurricane Katrina made New Orleanians believe that their risk was being managed and controlled. They could see that areas with repeated flooding from rainstorms were being improved—the areas of high frequency risk. However, in areas of low frequency but high consequence risk—the areas that suffered the most devastating flooding in the aftermath of Hurricane Katrina—residents had no risk information to weigh in making decisions about where to live.[6]

- In parts of the city like Broadmoor, which had experienced a history of repeated stormwater flooding because of low elevations and poor drainage infrastructure, conventional Army Corps strategies based

[6] This discussion is based on Earthea Nance, "Responding to Risk: The Making of Hazard Mitigation Strategy in Post-Hurricane Katrina New Orleans," *Journal of Contemporary Water Research & Education*, Issue 141 (March 2009), 21–30.

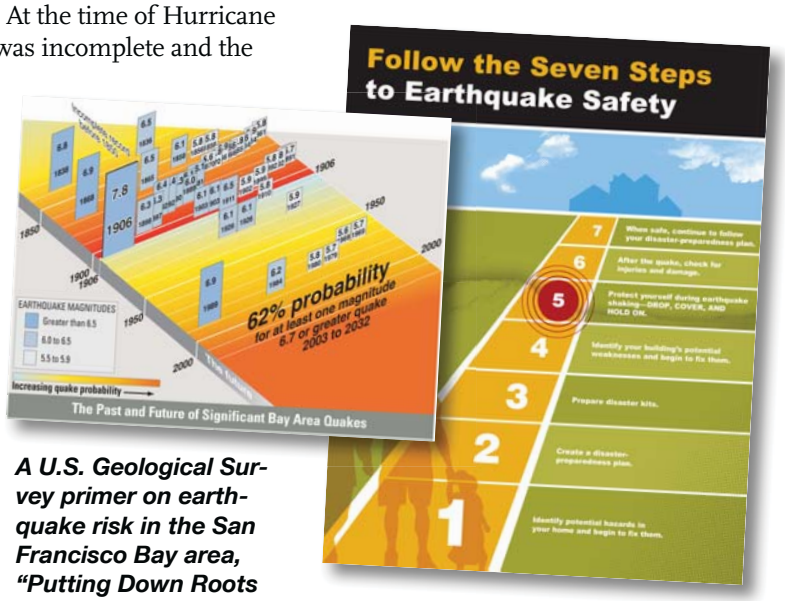
on structural improvements to the system along with funds to elevate and reconstruct homes with a history of repetitive flood losses were implemented after Hurricane Katrina.

- Neighborhoods like Gentilly, New Orleans East, and the Lower 9th Ward did not have a history of stormwater flooding and poor drainage (though individual properties still experienced repeated stormwater flooding depending on individual circumstances). The newer developments in New Orleans East were built with up to date drainage infrastructure and with man-made lakes to serve as stormwater retention ponds. This was also true of newer development on the West Bank. Before Hurricane Katrina, residents in the East had no reason to think their neighborhoods were especially flood-prone because they did not experience stormwater flooding during the deluges that periodically flooded other areas.

Because of historical building practices, most of the pre-war homes in the city were elevated above grade.

- City government and city residents believed that the system of levees, floodwalls and pumps designed, built and funded by the federal government would protect them from catastrophic storm consequences and, as a result, did not focus on land use strategies, stringent code enforcement and emergency preparedness because of a lessened sense of vulnerability. Within the levees, slab on grade became the norm in new construction and habitation of ground floor areas in elevated houses was allowed.
- Evacuation became a favored strategy to reduce hurricane impacts on populations. Because the science of weather prediction was much more precise, significant advance notice of hurricanes became possible. Communications media could disseminate information. At the same time, it was clear that many people would decide not to evacuate and the evacuation planning neglected the needs of residents with few resources, disabilities, illness or other problems. At the time of Hurricane Katrina, the state's Emergency Operations Plan was incomplete and the inadequacy of the federal response is well known.[7]

The catastrophe of Hurricane Katrina exposed weakness and failure in many areas of local, state and federal understanding and response. One of the fundamental lessons of Hurricane Katrina is that "the risks of the past are not the same as the risks of the future."[8] All levels of government are now engaged in new initiatives to apply the lessons of Hurricane Katrina, but the biggest challenge is to incorporate the adaptability and flexibility that is the true sign of resilience. New Orleans' historic response to disasters, "a return to the familiar," will not be enough.[9]



A U.S. Geological Survey primer on earthquake risk in the San Francisco Bay area, "Putting Down Roots in Earthquake Country," offers a good model for guidance on disaster preparedness. The full document is available at http://pubs.usgs.gov/gip/2005/15/gip-15.pdf

[7] Colten, *et al.*, p.9

[8] Nance, p. 21.

[9] Colten, *et al.*, p. 7.

As one of a worldwide group of cities located at major river deltas, New Orleans is particularly vulnerable to climate change and sea level rise. In addition, upstream management of the Mississippi River has implications for the city's future. In 2005, before Hurricane Katrina, the city was identified by a study as one of the top ten cities in the world in terms both of population exposure and asset exposure to coastal flooding, and it was projected to be one of the top 20 in the 2070s, in terms of asset exposure to coastal flooding, taking into account projected climate change and socioeconomic change. Other American cities identified as vulnerable in this study are Miami, New York, and Virginia Beach. European and Japanese cities tend to be less vulnerable because they have better protection levels: London, Tokyo and Amsterdam currently have protection to the 1-in-1,000-year storm standard—as does Shanghai—rather than the US level of the 1-in-100-year storm. The study pointed out that structural storm protection projects take a long time to put in place (some 30 years for the Thames Barrier that protects London) but that "all port cities require a combination of spatial planning and enhanced defences to manage the rising risk of sea level rise and storm surge with climate change."[10]

2. Post-Hurricane Katrina Analysis

In the wake of the 2005 protection failures, the Army Corps of Engineers set up a group to learn lessons and identify future risks, the Interagency Performance Evaluation Task Force, popularly known as IPET. The Corps also asked the National Academy of Engineering and the National Research Council to organize a committee to review IPET's draft reports. The final National Academy review, published in 2009, contained the following comments and recommendations:

- No protective structures can ever completely eliminate risk from flooding.
- Even though the pre-Hurricane Katrina system proved vulnerable, "it appears that reconstruction activities are taking place largely according to the system's pre-Hurricane Katrina footprint....at the very least, there should be discussions that consider the pros and cons of different designs and different levels of protection across the region."
- It will not be possible to provide equal degrees of protection across the city, as higher elevations are inherently safer than low-lying areas. Voluntary relocation, with adequate resources, should be considered for very vulnerable areas.
- Significant floodproofing is essential where people continue to live in vulnerable areas, such as elevation of houses to at least the 100-year storm level and strengthening of critical infrastructure.
- The 1-in-100-year flood protection standard is inadequate "for heavily-populated urban areas where the failure of protective structures would be catastrophic—such as New Orleans."
- Strategies to create shelters within neighborhoods for those unable to leave should be pursued in addition to comprehensive evacuation programs.
- Communicating risks to residents in laymen's terms is critical.
- An independent "second opinion" on the system should be solicited regularly.[11]

Through storm surge modeling prepared by IPET, New Orleans now has more and better information on its future flood risk than any other place in the world. We know where the levees are weak and what parts of the city are more vulnerable.[12] How the city, state, and federal governments use that information, and integrate it with community social, economic, cultural and political realities, will determine the future resilience of New Orleans.

[10] Nicholls, R.J. *et al*., "Ranking of the World's Cities Most Exposed to Coastal Flooding today and in the Future," Executive Summary of OECD Environment Working Paper No. 1, OECD (2007), www.oecd.org.

[11] National Academy of Sciences, *The New Orleans Hurricane Protection System: Assessing pre-Hurricane Katrina Vulnerability and Improving Mitigation and Preparedness*, Report in Brief, (2009), www.nap.edu.

[12] Nance, p. 24.

SOURCE: LAKE PONCHARTRAIN BASIN FOUNDATION

The multiple lines of defense strategy is a methodology to design flood control and wetland restoration that utilizes both manmade and natural features to ensure protection against hurricane surge.

3. Multiple Lines of Defense

A major lesson of Hurricane Katrina is that New Orleans cannot simply rely on bigger or better levees, gates, and pumps for protection. The city must become the expert in its own protection and resilience by adopting a strategy that addresses multiple lines of defense, some of which will require continued advocacy and vigilance, and some of which the city and it citizens can take charge of themselves. The multiple lines of defense range from restoration of coastal wetlands, to internal and external structures, to non-structural strategies (such as land use and building codes), to emergency preparedness.

A. THE BIG PICTURE: COASTAL RESTORATION

New Orleans' first measure of security from storm surge flooding relies on the health of the wetlands along Louisiana's coast. Research has suggested that every 2.7 miles of wetlands can absorb one foot of storm surge. Healthy wetlands also help to reduce hurricane wind speeds. Without the natural wetlands buffer, the New Orleans area would be directly exposed to wave action and the most severe storm surge from the Gulf of Mexico in a tropical event. Another benefit of wetlands is that they are the nurseries for Louisiana's commercial fishing and seafood industry.

Southeast Louisiana's coastal environment has suffered tremendously and needs substantial restoration efforts.

The health of Louisiana's coast has been declining for decades. It is estimated that Louisiana has lost more than 2,000,000 acres (or over 3,000 square miles) of its coast in the last 70 to 80 years alone. Levees along the Mississippi River have prevented flooding, but also prevent the river from disseminating its sediment, a key element of natural coastal land building processes. Construction of artificial channels for oil and gas drilling and other commercial purposes (most notably the Mississippi River Gulf Outlet) destroyed wetlands and contributed to saltwater intrusion from the Gulf (itself a cause of wetland loss). Finally, the introduction of non-native species, most notably the nutria from South America, also had a destructive effect on this sensitive ecology. It is estimated that if recent rates of coastal land loss are not substantially slowed or reversed in the next 10 years, the process may no longer be reversible.

On a small scale, the State of Louisiana has been involved in coastal restoration efforts since 1989 and limited federal involvement in coastal restoration began in 1990 with passage of the Breaux Act. After Hurricane Katrina, the importance of coastal wetlands for hurricane protection and Louisiana's future suddenly came to the

fore. In November 2005, the legislature created the Coastal Protection and Restoration Authority (CPRA) with the mission of coordinating local, state and federal agencies to achieve comprehensive protection and restoration, particularly through integrating activities in two previously separate areas, wetland restoration and flood control.[13] CPRA prepared a master plan for coastal protection and restoration. In 2006, the federal government agreed to share royalties from offshore oil exploration for coastal restoration.[14] Over the next 10 years, Louisiana will only receive approximately $20 million annually from outer continental shelf oil exploration royalties, but after 2017 the state is expected to realize as much as $650 million annually from this revenue source. Additional measures include the dedication of recent state surplus funds to coastal restoration projects, the federal Coastal Impact Assistance Program of 2005, and the inclusion of $1 to 2 billion for coastal restoration in the 2007 federal Water Resources Development Act (WRDA). These funding sources are supporting a wide variety of coastal restoration initiatives, such as freshwater diversion projects that direct Mississippi River sediment to rebuild marsh. Estimates of the total cost of restoration run as high as $45 billion.

New Orleans itself is home to tens of thousands of acres of wetlands, both federally protected in the Bayou Sauvage National Wildlife Refuge and privately owned. The Mayor's Office of Coastal and Environmental Affairs is responsible for implementing the 1985 Orleans Coastal Management Plan, oversight of wetlands restoration, coordination with other agencies, and has limited development review capacity. The Army Corps of Engineers' and the state Department of Natural Resources' criteria for permitting small developments in wetlands areas do not take into account the potential effects of cumulative small actions.

The accelerating loss of wetlands combined with slow progress in starting up projects has alarmed many coastal scientists. In 2009, a group of leading coastal scientists was reported to have concluded that unless Louisiana launches major projects within the decade, coastal erosion will advance so rapidly that there will be no realistic way to stop it.[15] One 2009 study suggested that dams and reservoirs upstream send only half the sediment to create coastal marshes at the delta in comparison to 100 years ago, and at the same time, sea levels are rising at three times the rate of 100 years ago. Some scientists say this study was too pessimistic, citing the role of plant organic material in extending wetland areas, but most agree that coastal restoration projects cannot completely bring back eroded wetlands.[16]

In June 2009, the Army Corps of Engineers released the Louisiana Coastal Protection and Restoration Study Final Technical Report. The purpose of the study was to present the range of flood control, coastal restoration and hurricane protection measures that would provide protection from a category 5 hurricane storm surge.

The National Research Council of the National Academy of Sciences reviewed this report and made these observations:

- The project does not provide a comprehensive plan of structural, nonstructural and coast-restoration actions and does not provide any recommendations on priorities and early actions.
- The report assumes that the current shoreline can be maintained without further erosion, but it does not provide enough analysis to justify this assumption or alternatives if the assumption proves erroneous.
- The report does not fully take into account the high degree of scientific uncertainty about certain aspects of wetlands restoration and the potential impacts of river diversions.
- Storm surge protection for New Orleans should be designed for hurricane storm surge events at the 1-in-400-year and 1-in-1,000-year levels.

[13] CPRA, Integrated Ecosystem Restoration and Hurricane Protection: Louisiana's Comprehensive Master Plan for a Sustainable Coast, Draft, (February 2007), Executive Summary.

[14] The Domenici-Landrieu Gulf of Mexico Energy Security Act of 2006.

[15] Mark Schleifstein, "Sense of urgency grips coastal restoration summit,"*The Times-Picayun*e, (March 04, 2009).

[16] Mark Schleifstein, "LSU researchers: coastal restoration projects doomed to fail," *The Times-Picayune* (June 29, 2009O.

- No discussion of the probability of failure in any of the structural systems (levees, *etc.*) was included.
- The Corps should promote nonstructural measures (such as public education about differing flood risks, and development regulations) more aggressively and should engage with local and state governments more in order to discourage development in vulnerable areas.
- Ecosystem restoration and hurricane protection should be approached in a much more holistic way than the current system of multiple federal authorizations to the Corps for specific projects.[17]

The National Academy suggests the Comprehensive Everglades Restoration Plan as a model for southeastern Louisiana. "The LACPR (Louisiana Coastal Protection and Restoration Program) is similar to the Everglades Restoration Plan in its spatial extent, hydrologic and ecologic complexity, and uncertainties regarding outcomes of future ecosystem restoration and hurricane protection efforts."[18]

B. PROTECTION AND RESILIENCE ON THE CITY AND COMMUNITY LEVEL

The traditional arena of structural protection is where most immediate attention, effort and funding have been applied since Hurricane Katrina. Structural protections will always be necessary in New Orleans and real progress is being made in the quality of the city's levees, flood gates, and floodwalls. In a series of post-Hurricane Katrina spending bills, Congress appropriated over $14 billion to repair the region's levee system and ultimately improve the system to provide robust protection from a 1-in-100-year storm. Repairs and improvements completed since Hurricane Katrina include:

Temporary flood gates at the mouths of the outfall drainage canals have significantly reduced the risk of flooding in certain neighborhoods since Hurricane Katrina.

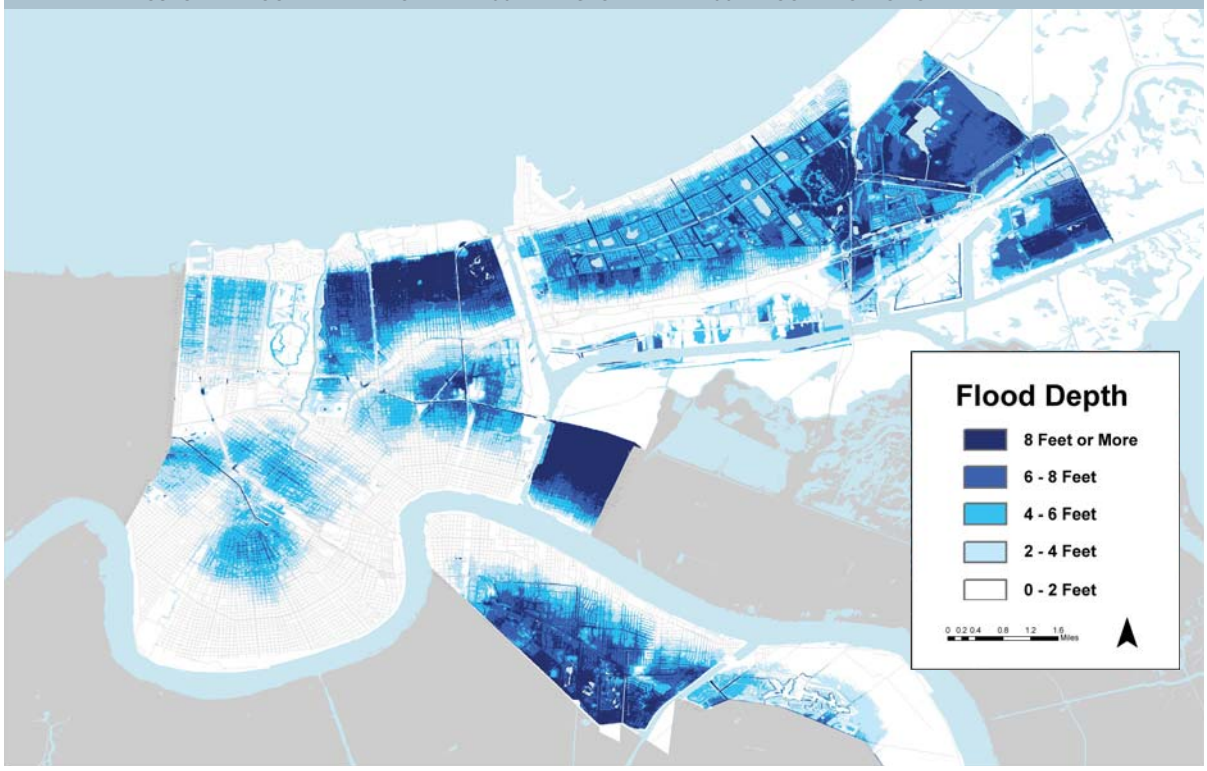
- The installation of flood gates at the mouths of the city's drainage canals to prevent storm surge from entering the heart of the city
- Raising the height of numerous levees
- Repairing levees and floodwalls that were breached during Hurricane Katrina
- Strengthening floodwalls to add a higher margin for safety
- Adopting an overall higher standard for the structural integrity of levees and floodwalls in their design and construction

According to detailed flood models prepared by the Army Corps of Engineers, these investments have already made real improvements in the degree of flood safety in numerous neighborhoods of the city. The flood maps on the next pages, released by the Corps' Interagency Performance Evaluation Taskforce (IPET), illustrate improved flood scenarios for various areas of the city before and after the interim improvements were completed. When the 100-year flood protection system is completed in 2011, flooding would be minimal throughout the city in the event of a 100-year storm. Even with a system designed only for a 1-in-100-year storm, the city would still be considerably more protected than it is today, and receive less flooding, even from a 1-in-500-year event than it did during Hurricane Katrina ***(see map).*** This suggests that if the levee improvements underway are paired with appropriate building practices, New Orleans could realize a significant improvement in its overall security from storm surge even prior to the implementation of a 500-year external flood protection system.

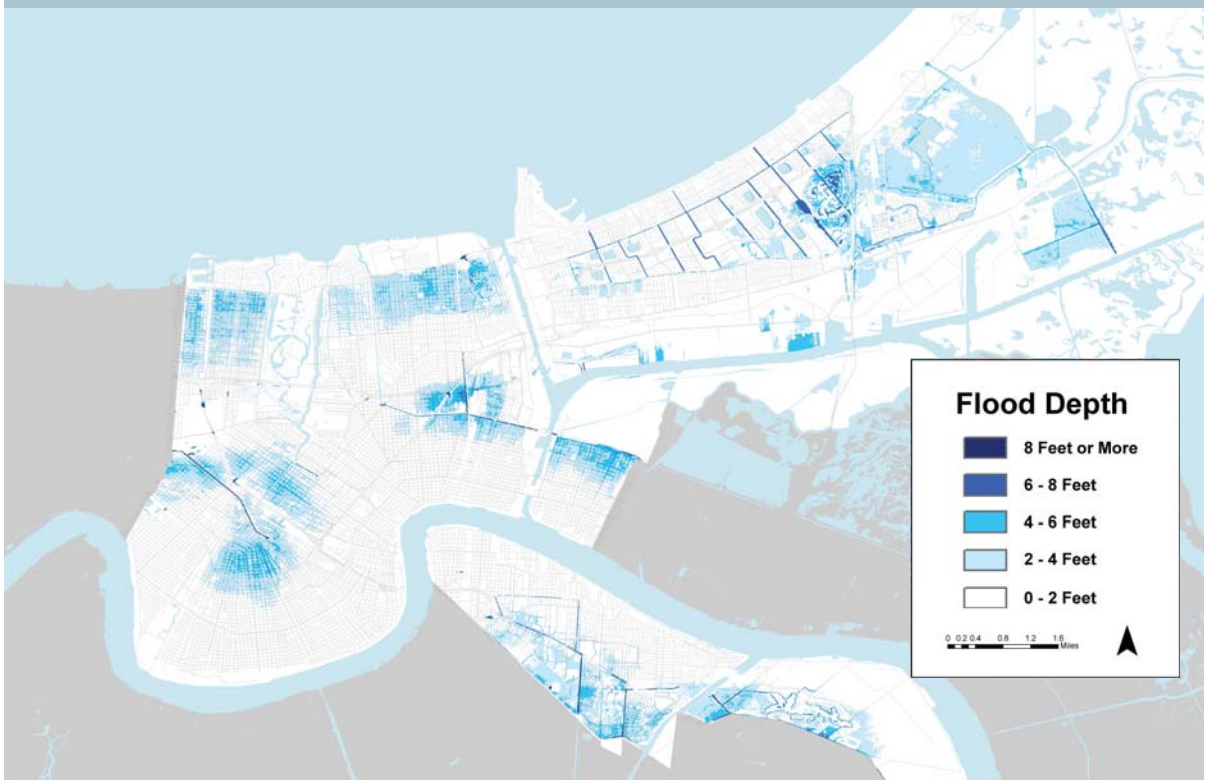
[17] *Final Report from the NRC Committee on the Review of the Louisiana Coastal Protection and Restoration (LACPR) Program*, National Research Council, 2009, www.nap.edu/catalog/12708.html.

[18] *Ibid.*, p. 29.

MAP 12.1: PROJECTED FLOOD DEPTH FROM 1-IN-100-YEAR STORM WITH 2007 FLOOD PROTECTION

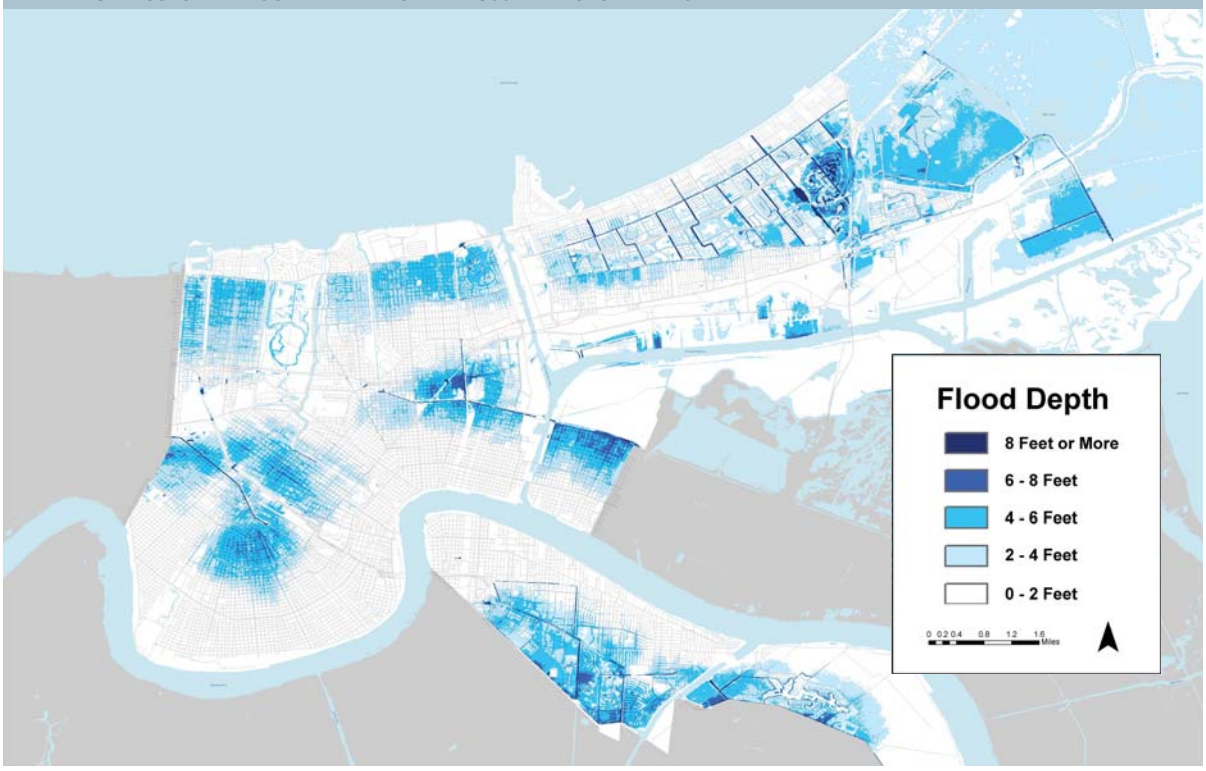


MAP 12.2: PROJECTED FLOOD DEPTH FROM 1-IN-100-YEAR STORM IN 2011

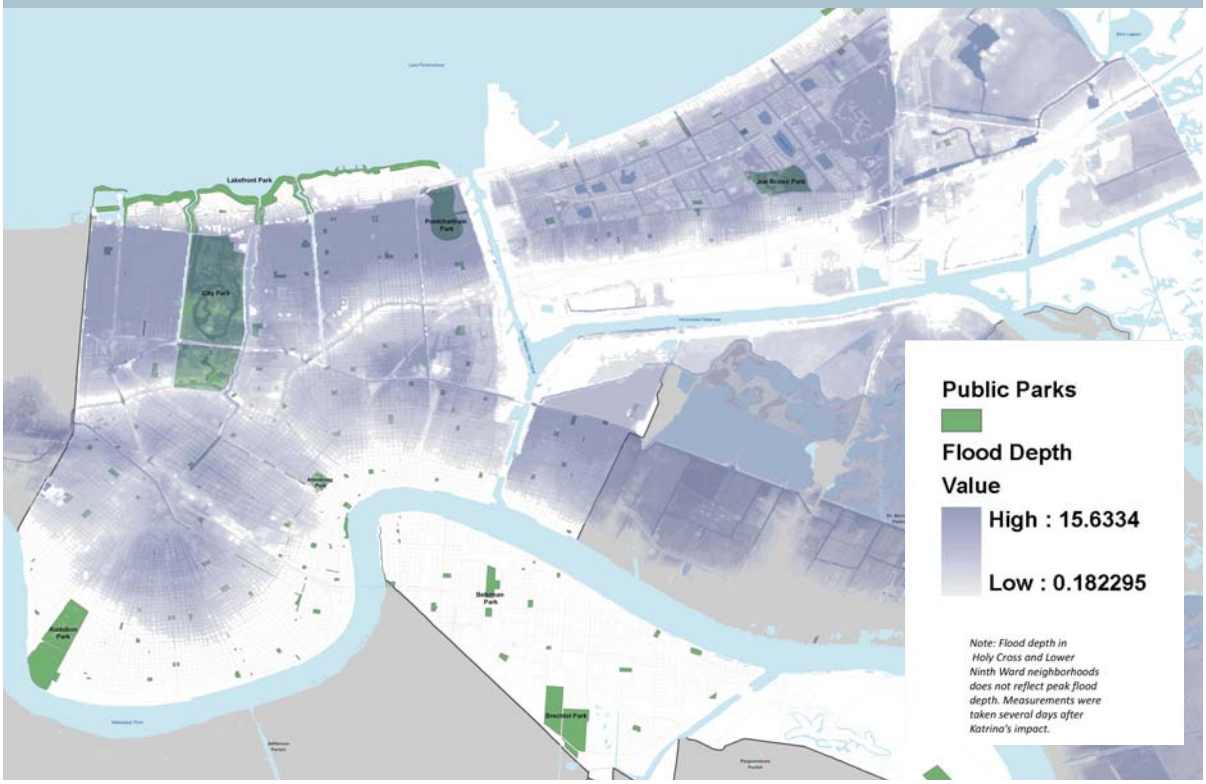


When the 100-year hurricane protection system is complete in 2011, the Corps of Engineers anticipates that New Orleans will experience only minimal flooding from a 100-year storm, assuming no pumping.

MAP 12.3: PROJECTED FLOOD DEPTH FROM 1-IN-500-YEAR STORM IN 2011



MAP 12.4: HURRICANE KATRINA FLOOD DEPTH



When the 100-year hurricane protection system is in place, New Orleans should experience substantially less flooding than it did during Hurricane Katrina, an estimated 300-year-plus event.

As noted earlier, in the second half of the twentieth century, decisions on where buildings were located and how they were built across the city had implications for protection from both high frequency/low consequences flooding and low frequency/high consequences flooding. Instead of densifying the higher ground neighborhoods close to the banks of the Mississippi River or focusing on successful revitalization of troubled "dry" neighborhoods, middle class and working class New Orleanians left the city core for suburban-style, somewhat less dense neighborhoods, and ignored the city's tradition of building at least a few feet above grade—assuming that the levees would protect them.

The slab-on-grade home became the dominant new residential building type after World War II.

The individualized resettlement pattern emerging since the storm has set expectations for the return of neighborhoods that existed pre-Hurricane Katrina. In that sense, the response to the Hurricane Katrina catastrophe resembles New Orleans' traditional approach—a return to the familiar. For numerous reasons, it makes sense to ratify the commitment to rebuilding and protecting the neighborhoods that existed before Hurricane Katrina. However, as this Master Plan has recommended in previous chapters, the city should focus on infill development rather than extending new subdivisions, and apply and enforce new requirements to ensure greater protection and resilience.

An official Orleans Parish Hazard Mitigation Plan was adopted in December 2005 and an update is in preparation as of mid-2009.[19] The city's Hazard Mitigation Unit, within the Office of Homeland Security and Emergency Preparedness has the following objectives:

- Communicate hazards and risks to New Orleans residents in coordination with the Office of Emergency Preparedness, the Office of Communications, the Office of Recovery, the LRA, Governor's Office of Homeland Security and Emergency Preparedness, FEMA, and the Army Corps of Engineers.
- Develop comprehensive solutions, policies, and programs to manage hazards and risks in coordination with the Department of Safety and Permits, the Office of Emergency Preparedness, and the City Planning Commission.
- Build long-term City capacity in hazard mitigation and risk reduction, including acquiring funds for hazard mitigation projects.
- Include knowledge about hazards and risks in city planning and project development processes.
- Incorporate hazard mitigation and risk reduction principles and requirements into the City's Master Plan and Municipal Code.

The City is pursuing two lines of action in hazard mitigation that reflect the two types of flood-risk areas described earlier—high-frequency flood risk and low-frequency but high-consequence flood risk. Ensuring that the City takes advantage of the conventional FEMA programs based on the highest number of repeated flood insurance claims represents one line of action. Grant programs are available for this type of mitigation, and the City is already maximizing its participation in these programs. The other approach is to seek FEMA and other funds to develop a non-structural program for areas of highest risk with incentives to promote land use and building practices that provide more protection. Much less funding is available for these kinds of initiatives. A series of pilot programs is planned that will focus on the 17 Target Recovery Areas. It will consist of demonstration projects of the following types:

- Property buyouts in low-lying/high-risk areas and relocation to new elevated structures in the same or adjacent neighborhoods

[19] The following discussion on the City's hazard mitigation planning and programs is based on Nance, pp. 26–29.

- Elevation of structures in place (maximum of 12 to 15 feet)
- Secondary levees and floodwalls up to 6 feet around critical public facilities or commercial buildings
- Dry flood proofing of commercial buildings (installation of external waterproof walls up to 4 feet in areas with a history of not more than 3 feet of flooding)
- Hardening of critical facilities through elevating pumps, generators, electrical wiring, *etc.*, and moving operations above the first floor.

These mitigations are included in the non-structural section of the LACPR Final Report.[20] In 2009, some projects are already being implemented through capital projects, programs and initiatives of other City agencies, authorities and some nonprofit organizations. New public facilities, especially public safety and emergency facilities, are being designed to withstand 500-year storms. The houses in NORA's first residential project in Pontchartrain Park were purchased from homeowners and are being rebuilt at appropriate elevations, with sustainable elements. The Make It Right organization has been building elevated houses in the Lower 9th Ward and recently purchased more lots through NORA to continue rebuilding in that neighborhood. The City is assisting approximately 150 homeowners with elevation or reconstruction of their at-risk homes and is working with the Sewerage and Water Board to mitigate pump stations.

Key public facilities must be retrofitted and "hardened" to ensure their flood and wind resilience in the event of a future major storm.

Other action items in the City's current hazard mitigation plan include:

- Enhance the levee system to withstand a Category 5 Hurricane
- Establish a role for the Parish to review the maintenance and strength of the levee system
- Make the city code consistent with FEMA requirements
- Develop and maintain a comprehensive GIS system that includes data needed to plan, prepare and recover from disaster
- Enhance public awareness and understanding through a public service media campaign, speakers bureau to provide presentation to community groups, promoting purchase of flood insurance, and other methods
- Develop a comprehensive program to protect vital records
- Participate in all regional and state efforts for coastal restoration

The focus of Volume 2, Chapter 12 is on strategies that would eventually eliminate the need for large-scale evacuation. However, until these and other strategies are fully implemented, evacuation will remain an important component of ensuring resilience. Since Hurricane Katrina, hurricane emergency policy has focused on mandatory evacuations for storms of Category 3 or above. Although the city's 2005 Hazard Mitigation Plan called for the establishment of shelters of last resort in each Planning District, these were deemed unlawful because of changes in federal law. The City's Office of Homeland Security and Emergency Preparedness is in charge of evacuation procedures and provides information on how individuals and families can be ready for evacuation. The City has established the City-Assisted Evacuation Plan for persons who need transportation and other help in evacuation and it has formed volunteer groups who go through

[20] www.lacpr.nsace.army.mil/FinalReport/Vol%201/Nonstructural%20Plan%20Component.pdf

training in disaster preparedness and evacuation assistance. Several neighborhood groups have produced neighborhood-based evacuation and disaster response plans. One group of residents has proposed a citywide system of neighborhood groups to coordinate evacuation and disaster preparedness at the household level through annual plans; coordination with public agencies; and sponsorship of residents for training. Existing neighborhood associations or proposed community participation program groups could take on these responsibilities.

Large expanses of impervious surfaces exacerbate stormwater drainage problems and soil subsidence.

The evacuation experience in advance of Hurricane Gustav in 2008 was in some respects a success. Those with transportation took the "contraflow" routes out of the city to shelters run by nonprofit institutions or to their preferred locations. However, people unable to secure transportation were put in buses by the state, not told where they were going, and then deposited in locations such as empty warehouses and big box stores for a week without adequate services. Although plans have now been made to correct these problems, the experience created a disincentive that will discourage some people from participating in the next mandatory evacuation. For people of modest means, the cost of evacuation in lost income and extra expenses can be particularly difficult, but evacuation as a regular event is costly and disruptive for all residents and businesses. Another lesson learned from the Gustav experience was the danger posed by vessels in the city's canals. Vessels will have to be secured or moved upriver, or the Coast Guard will sink them on site.

Finally, unlike cities in the Netherlands and elsewhere, New Orleans does not take advantage of the possible amenity value of its stormwater infrastructure. New Orleans receives about 62 inches of rain a year, often in monsoon-like torrents to be expected in its semitropical climate, temporarily overwhelming drainage and pumping systems. This is the high-frequency flooding that affected Broadmoor and some other locations around the city. Dependence on traditional stormwater management that takes the water through concrete channels to be pumped into the lake or river has also depleted groundwater and increased subsidence. Subsidence causes damage to public infrastructure and private structures and puts neighborhoods at greater risk by lowering their ground elevation. Other cities around the world that face subsidence issues, such as Tokyo, have successfully mitigated soil subsidence through the use of pervious materials and through other groundwater management techniques. Natural drainage systems ***(also discussed in Chapter 8)*** also have the advantage of being less costly than hard infrastructure and providing the amenity value of plantings.

Fears of mosquito-borne disease and similar threats have historically justified burying and hiding the city's canals and drainageways, but the use of artificial lakes for stormwater storage in newer neighborhoods like New Orleans East demonstrates that modern approaches to stormwater management can also create neighborhood amenities without health threats.

C. HAZARD MITIGATION AND RESILIENCE IN THE NEIGHBORHOOD, ON THE BLOCK AND AT HOME

Land use

Although the city has zoned thousands of acres of low-lying land for additional development, the focus of this Master Plan is on the next 20 years and enhancement of existing neighborhoods. In other chapters of this plan, recommendations for land use restrictions and a wetlands protection ordinance are discussed to restrain further expansion of the city's urbanized area into low-lying land. Nature-based or recreational uses of these lands is suitable, as would be conservation protections. With the development of a national carbon cap-and-trade system underway at the time of writing, this land could become valuable as a source of carbon credits to be traded for pollution offsets.

Further expansion of development into low-lying areas is not advisable.

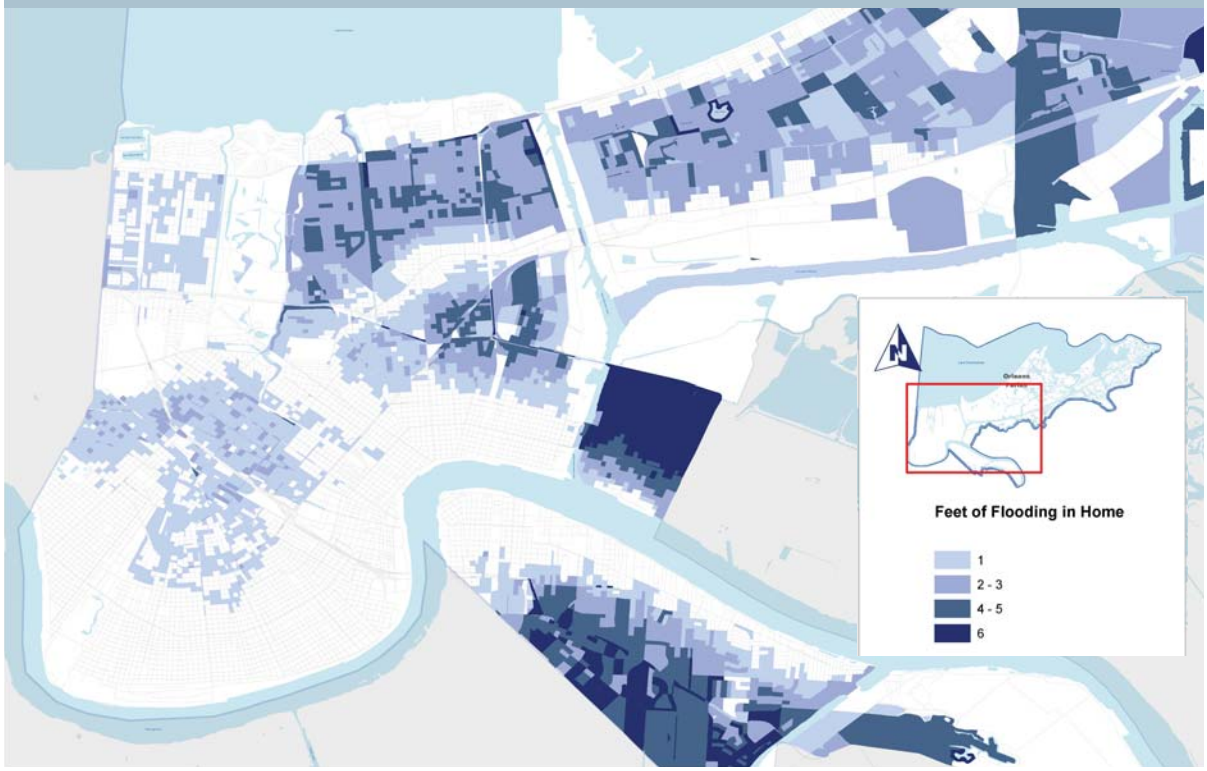
Elevating buildings

Elevating buildings is an effective, self-guided way of further reducing flood risk. Elevation requirements for new structures are governed by the Advisory Base Flood Elevations (ABFE's) that the City Council enacted in 2006. To mitigate the risk of flooding and to limit the potential exposure of taxpayers, FEMA delineates Special Flood Hazard Areas or "flood zones" and prescribes a certain minimum building elevation within the flood zone to protect structures from an estimated 1-in-100-year flood. The enforcement of this elevation requirement by local governments is mandatory if a community wishes to remain eligible for the National Flood Insurance Program. The elevation requirement is triggered when a new structure is built and when a renovation exceeds 50% of the value of the pre-existing structure. In 2011, after the 100-year flood protection system has been completed, FEMA will recalibrate its flood maps and recommended elevations; and FEMA will mandate adoption of the new elevation standards for coastal communities who wish to continue to participate in the National Flood Insurance Program (NFIP).

As the National Academy of Science report noted, a 1-in-100-year standard for flood resilience is insufficient for New Orleans. ABFE requirements in New Orleans assume the perfect operation of the external flood protection system and the internal drainage pumps. However, when that system fails, as during Hurricane Katrina, these requirements are woefully insufficient in offering protection to properties. Indeed, many properties that were perfectly in compliance with the base flood elevation requirements were still badly flooded from Hurricane Katrina. And because much of New Orleans' population lives at or below sea level, flood waters do not subside quickly and must be pumped out. Another problem with current base flood elevation standards is that there is no acknowledgment of the intermediate nature of the city's current flood protection system. The system will not be completed to a 1-in-100-year standard until 2011; yet upon their adoption in 2006, the ABFE's essentially proceeded as though 100-year storm protection were already in place. This highlights the potential need for additional elevation between now and the completion of the 100-year hurricane protection system in 2011. However, upon completion of the levee system, these additional elevations would no longer be necessary in some areas of the city. This highlights the dilemma faced by New Orleans as it awaits 100-year levee protection—the situation is changing and it is difficult to impose additional expenditures on individuals living in parts of the city whose levees are the last to be improved by the Army Corps of Engineers at public expense.

As discussed earlier, the IPET maps project that much of the city would be dry or only minimally flooded in the event of a 500-year storm, once the 100-year hurricane protection system is completed in 2011.

MAP 12.5: AMOUNT OF FLOODING IN ABFE-COMPLIANT HOMES ACCORDING TO 2007 RISK OF A 1 IN 100-YEAR STORM



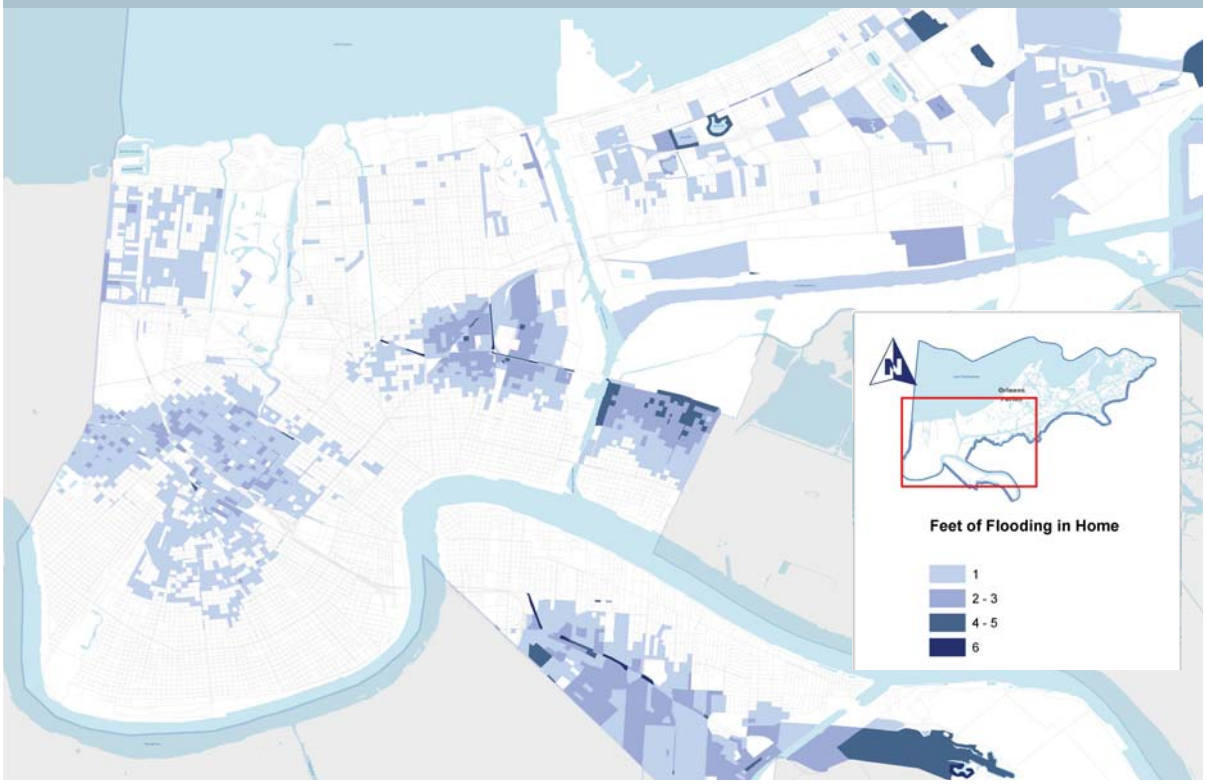
This map illustrates those blocks whose ABFE-compliant structures would still experience flooding in the event of a 1-in-100-year storm with the 2007 level of flood protection in place. While the ABFE regulations provide an additional margin of protection for many areas of the city, this map shows that there are many neighborhoods whose structures would still be at risk in the event of a 100-year storm.

There are some areas, however, that would still be substantially affected. By requiring a moderate level of elevation throughout the city and a greater level of elevation in the few most vulnerable areas, the city would essentially be working toward a de facto 500-year level of protection for new residences and businesses. Maps 12.5 and 12.6 highlight those areas of the city where higher flood elevations (generally speaking, greater than 3' above grade) could be required. The city can pursue this strategy of mandating higher elevations in several ways. The city can work proactively with FEMA to craft unique flood elevation requirements for New Orleans that would hold new construction to a 1-in-500-year level of protection. Alternately, the city could simply enact local elevation requirements within the city's building code to supplement federal regulations.

Retrofitting existing structures to meet more stringent elevation requirements is one component of making the city more flood resistant.

However, the "trigger" for greater building elevation requirements would only be as new structures are built or as older structures are substantially renovated. Extant structures, pre-dating the more stringent requirements, would still remain vulnerable. Because most programs to assist property owners require evidence of past damage, funding is more difficult to obtain for owners of existing properties that do not fit damage requirements. FEMA has one program, the Pre-Disaster Mitigation Grant Program, which is focused on avoidance of

MAP 12.6: AMOUNT OF FLOODING IN ABFE-COMPLIANT HOMES ACCORDING TO PRESENT RISK OF A 1 IN 100-YEAR STORM



This map illustrates those blocks whose houses would have to be elevated beyond existing Advisory Base Flood Elevations to avoid flooding from a 500-year storm once the 100-year protection system is in place in 2011. Note that relatively few areas would be required to elevate structures beyond the existing elevation standards to achieve a much higher level of protection.

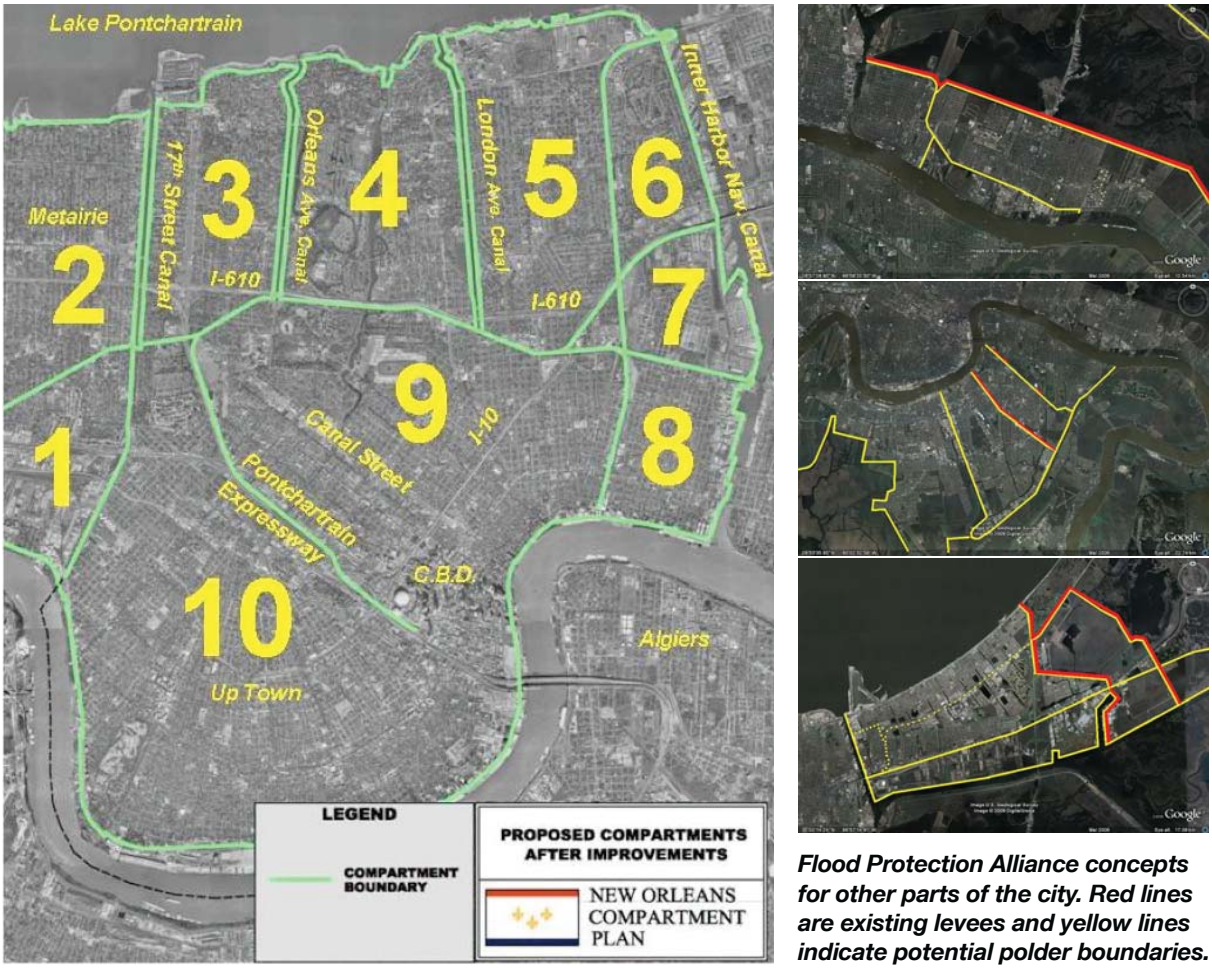
future costs and could benefit New Orleans property owners who do not meet criteria for other programs. There are a number of federally-funded programs administered by state or local government that are available to assist in elevation and other hazard mitigation costs. As of 2009, the City's Hazard Mitigation Unit had obtained over $61 million in federal grants under four programs: Hazard Mitigation Program; Severe Repetitive Loss Program; Planning Pilot Program; and the Pre-Disaster Mitigation Program. These programs can be used for acquisition and demolition; acquisition and relocation; elevation; floodproofing; and minor flood reduction projects. Some of the programs can also be used for infrastructure and structural retrofitting, and even post-disaster code enforcement. In addition, Road Home elevation grants administered by the State were newly available as of 2009 and individuals could apply to FEMA for the Increased Cost of Compliance Program, both of which offer up to $30,000, if certain conditions are met.

4. Proposed new models for New Orleans: learning from the Dutch

The Hurricane Katrina catastrophe jolted New Orleans out of the 40 years of complacent belief that the federal levee system would always protect them. The post-World War II reliance on single engineering solutions gave way to a greater understanding of the interconnectedness of policies affecting coastal wetlands, land use, drainage systems, and building styles. New Orleanians began to look around for new models of how to live with water. They looked especially to the Netherlands, because the Dutch have been living below sea level for centuries.

One new proposal was to create "polders" on the Dutch model. Dutch polders are areas of land reclaimed from the sea and surrounded by dikes that keep out the water. The Flood Protection Alliance, which was created by the Business Council of New Orleans and the River Region, has proposed a polder system for New Orleans and Jefferson Parish west of the Industrial Canal. Despite many low-lying areas susceptible to flooding, these areas also include a number of elevated natural and man-made features: ridges, drainage canal levees, remnant levees and railroad rights of way. Because these features intersect at right angles, they can "convert the bowl into a muffin pan," creating areas that, if flooded by breaches or other circumstances, will contain the flood water so it does not flow to other parts of the city. Underpasses and similar gaps would need to be fitted with flaps or similar systems to create this system of inner levees. The total estimated cost is $75–$100 million for the area west of the industrial canal.[21] The Flood Protection Alliance has begun to expand the concept to the West Bank and the city east of the Industrial Canal.

Another source of inspiration from the Netherlands has come through a series of meetings involving Sen. Mary Landrieu and other government officials and design, engineering, and hydrology experts from both the Netherlands and Louisiana. The "Dutch Dialogues" are a series of workshops to exchange ideas about the potential for New Orleans to learn to live with water both through respecting its power and through finding ways to enjoy it as an amenity.



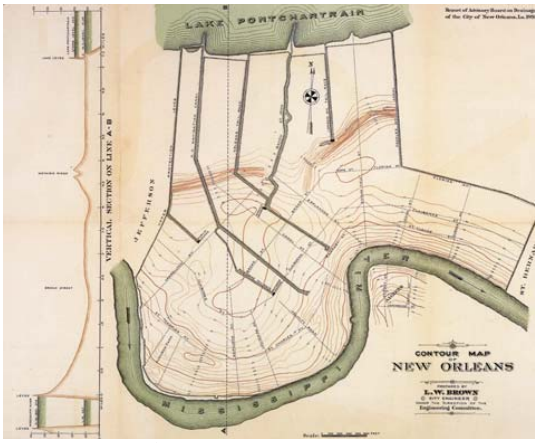
Flood Protection Alliance concepts for other parts of the city. Red lines are existing levees and yellow lines indicate potential polder boundaries.

[21] "Inner Levees, Inner Peace," typescript and image, courtesy of the Flood Plain Alliance, June 2009.

Water Planning in New Orleans

Living with Water

"Living with the water" has become an ordering, corollary principle of Dutch policy. South Louisiana, like the Netherlands, must adapt to the threats inherent to living in a subsiding delta. This is not an either/or proposition, it is an ordering principle. "Safety First" is the key organizing water management principle in the Netherlands as it must be here. History repeatedly shows the folly of living in a delta: disasters are common there. To ignore, however, the water's magic, the unique, abundant opportunities that can and should be exploited for economic, societal and cultural gain, is equally foolhardy. New Orleans has turned its back on its water and thus its nature, viewing it as a menace or nuisance, yet historical connections to water still exist within the city. Navigation and drainage canals and bayous have been covered, walled and hidden. Restoration of these waterways is feasible because rights of way still exist and are unencumbered. Bayou St. John is a vivid example of an attractive, historic waterway that could be a model for future canal restorations. Both safety and amenity from water are crucial to a future in which New Orleans is robust, vibrant and secure.



Countour Map of New Orleans, 1895[3]


Carondelet Canal Turning Basin, 1900[2]


Same Site, 1994[2]


Oude Haven, Rotterdam, NL, 2008[2]


Louisiana


Netherlands


Marsh Resoration, St. Bernard Parish Planning[1]


Potential Typical Neutral Ground with Canal


Potential London Avenue Canal

All images courtesy of Waggonner & Ball Architects
and taken from *Dutch Dialogues*, unless otherwise noted:
1 - St. Bernard Parish Planning, Waggonner & Ball Architects
2 - Richard Campanella, *New Orleans: Then and Now*
3 - *Charting Louisiana: 400 Years of Maps*

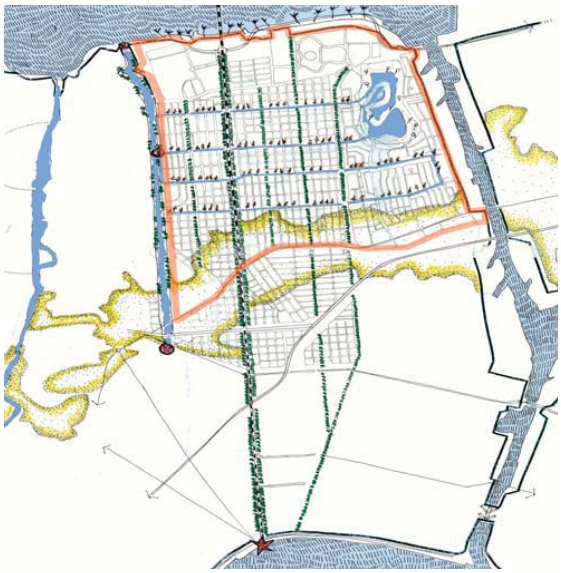
Water Planning in New Orleans

Systematic Approach

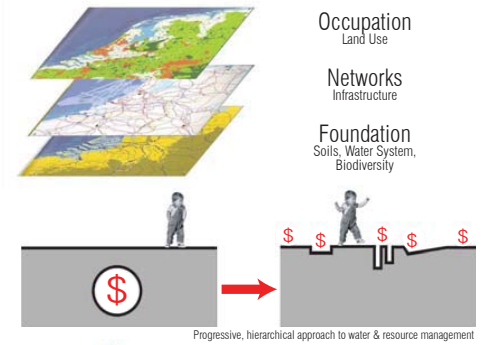
An integrated, holistic approach to planning at all scales, with water infrastructure as its foundation, is necessary in New Orleans. Stormwater, rainwater, groundwater and sea level rise risks must be identified and mitigated. Periodic rainfall as well as hurricane-driven repetitive loss rates must be reduced for human as well as economic reasons. Gates and pumps at the lakefront or near the water's edge need to be designed as all-purpose stations, replacing internal Sewerage and Water Board pump stations and allowing removal of concrete walls along the outfall canals. Consideration should be given to compartmentalization, or division, of the overall bowl into sub-basins to limit the potential for catastrophic citywide flooding from a single levee failure. The internal landform should be designed to accommodate maximum hourly rainfall, projected duration of rainfall design event, and potential levee overtopping. Storm water control should enhance retention, facilitate groundwater balance, reduce polluted discharge, decrease reliance on pumping capacity and create useful and attractive public space. The stabilization of groundwater can reduce subsidence and stresses on infrastructure. Opportunities for water storage exist in vacant sites, backyards, rooftops and parking lots, while existing and previously covered waterways and canals could be restored. A potential blue water network coordinated with green space can provide ecological balance and space for water storage, as well as quality of life and economic opportunities. Safety, stormwater storage, a healthy environment and a high quality of life are the principles that underpin a sound water planning approach.

Water Planning Principles:

1. Safety First
2. Resilient and Adaptable
3. Attractive and Sustainable
4. Risk Reduction and Economic Value are Linked
5. Water Storage Opportunities are Utilized

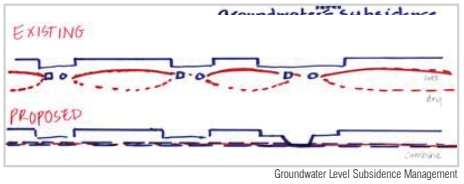


Map of the Gentilly Polder

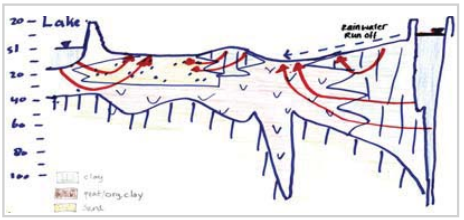


Progressive, hierarchical approach to water & resource management

Retain - Store - Drain



Groundwater Level Subsidence Management



Subsidence and Geomorphology

Hoffman Triangle: Potential Plan with Circulating Water

Felicity Street: Present

Felicity Street: Future "Normal" Situation

Felicity Street: Future Storm Water Storage

B What The Public Said

Safety and confidence in the city's storm protection system was a critical priority in all the post-Hurricane Katrina planning documents and during the Master Plan process. The following issues emerged:

- Safety needs to be a priority—hurricane protection, flood protection, personal, neighborhood safety.
- Protect the city so evacuation isn't always necessary.
- Adopt flood control systems used in other cities/countries that are below sea level.
- Protect and restore local and regional wetlands.
- Improve stormwater drainage and pumping systems.
- Require multi-tiered emergency planning for evacuation and shelter with residents input.
- Provide storm shelters within the city.
- Adopt building code standards that stand up to hurricane conditions (like in Florida).
- Report drainage problems and help enforce code violations.
- Use more pervious surfaces and less concrete.
- Use landscaping and tree planting strategies to mitigate runoff.
- Create retention ponds and catch basins to manage storm water.
- Elevate buildings and livable space.
- Install generators on-site, and elevate building systems above likely flood levels.
- Adopt the "Dutch system" of water management (*i.e.*, hold more water in the city with canals and retention ponds).
- Maintain water management facilities and infrastructure.
- Advocate for federal funding and accountability for flood protection.
- Educate the public about risk levels.
- Offer incentives to property owners to address flood mitigation and water retention on-site.
- Identify risk areas and encourage development in more flood-resistant areas.
- Set minimum building levels above flood levels.
- Take a comprehensive "systems approach" to dealing with water.
- Ambitious building elevation requirements are essential. Base flood elevation requirements are not enough.